PHRC Report #25: An Optimization Analysis of Residential Energy Systems

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Author(s): M. G. Suchar, G. K. Yuill, H. B. Manbeck, J. H. Willenbrock, H. E. Carr, Jr. - Consultant Support Staff

BACKGROUND:

Many energy efficient materials, mechanical systems and construction techniques that are currently available to the residential building industry are cost effective investments which do not detract from the quality of the living space. The benefits of such measurements will not be completely realized until the home buying public and the parties involved in the design/construction process become more educated about the energy and cost issues associated with these choices.

In a previous research project (PHRC Research Series Report No. 22, entitled "Analysis of Envelope Performance and Energy Utilization in Residential Construction"), life cycle cost optimization studies were performed on a particular prototype house design in a specific location (Williamsport, PA). The energy related factors that were considered included insulation levels, windows, air tightness and heating systems.

This research project continued the methodology developed in Report No. 22 but greatly expanded the scope of the investigation by considering two actual "Case Study" house designs (House A = 3000 ft^2, House B = 2000 ft^2) and a hypothetical 1500 ft^2 model. Eight basic heating and cooling equipment options were "installed" in these houses by using both Elite (The Bin Method) and the HAP computer simulation programs.

These houses were "located" in 22 different cities in Pennsylvania in order to represent a broad range of weather conditions. When different electric and gas utility rates were considered in those cities, a total of 44 different weather-utility combinations provided data for the analysis.

SUMMARY OF RESULTS:

A number of generalized conclusions can be reached based upon the studies that were performed in this research. They are listed below. It is important to note that these conclusions are only applicable for the cases and climates in Pennsylvania that were studied and the assumptions that were made. Although the methodology used in the studies can be applied, the conclusions are not appropriate for other locations in the United States.

- High efficiency air source heat pumps and high efficiency gas-fired furnaces with high

efficiency air conditioners are the most cost effective systems to install.

- High efficiency air source heat pumps are the most effective system to install in almost all smaller-sized homes (1500 ft^2 and 2000 ft^2).
- High efficiency gas furnaces combined with high efficiency air conditioners are most effective when installed in larger-sized homes (3000 ft^2) located in the coldest climates in Pennsylvania with associated low gas/electric price ratios.
- Air source heat pumps with gas furnace backup systems, ground source heat pumps, and electric baseboard systems with air conditioning are less cost effective in any sized home in the absence of utility subsidies.
- The results presented in this report, generally speaking, were the same whether HAP, Elite, or the field data adjusted energy usage approach was utilized.
- Relationships developed and presented in graphical form can be used by a builder to determine the optimum system and savings when the variables assumed in this study change.

WHAT IT MEANS TO YOU:

These research results will enable the home buying public, and the parties involved in the design/construction process, to use the decision matrix provided to make more intelligent choices about the most cost effective heating and cooling system options to install in various geographical areas in Pennsylvania.

WHAT'S NEXT?

A continuation project, which would benefit from the results obtained in this project, could focus attention on:

- materials selection, such as insulation, building envelope and window types
- proper construction techniques, such as air tightness control

The deliverable of this project would provide an expanded design matrix which incorporates these factors.